Job Preparation for the 21st Century Warfighter: Lessons from Patriot after Operation Iraqi Freedom

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Introduction

Background

During the combat operations phase of Operation Iraqi Freedom (OIF), Army Patriot units were involved in two fratricide incidents. In the first, a British Tornado was misclassified as an anti-radiation missile (ARM) and subsequently engaged and destroyed. The second fratricide incident involved a Navy F/A-18 that was misclassified as a tactical ballistic missile (TBM) and also engaged and destroyed. Three flight crew members lost their lives in these incidents. OIF involved a total of 11 Patriot engagements by U.S. units. Of these 11, nine resulted in successful TBM engagements; the other two were fratricides.

Patriot is the Army's first-line air and missile defense (AMD) system. The system has been in the active force since the early 1980s. Initially, Patriot was intended as a defense against conventional air-breathing threats (ABTs). However, since Operation Desert Storm (ODS) in the early 1990s, the system has been used primarily against TBMs. Future usage scenarios envision the system being used against a spectrum of air threats including TBMs, conventional ABTs, cruise missiles, and various categories of unmanned aerial vehicles (UAVs). The range of potential air threats in the contemporary battlespace has significantly increased the complexity of the battle command problem for Patriot and other AMD systems.

Since Patriot is an existing system and has been in the Army's inventory since the early 1980s, what do lessons from Patriot tell us about job preparation for the 21st century warfighter? As Patriot has evolved over the past two decades, the system has acquired features and characteristics that are more typical of systems the Army will employ in the future than those in the current inventory. Terms that are now used to describe Patriot include (1) joint, (2) network-centric, (3) complex, and (4) knowledge-intensive. First, command and control (C2) for the Patriot system is joint—involving both the Army and Air Force, and sometimes the Navy. Second, effective employment of system assets is dependent on a robust network. Third, the system as broadly defined is complex in that it consists of a large number of interacting components. And fourth, Patriot is knowledge-intensive in terms of the amount of information required to characterize and comprehend the system. Patriot thus provides a glimpse into the human performance requirements and problems likely to be faced by future warfighters. Moreover, this glimpse into the future is tangible and real and not abstract or hypothetical. The lessons discussed in this paper are from the crucible of combat operations and not based solely on the results of operational tests or simulated exercises. The paper has an admittedly Army focus, but the observations are general and apply to other classes of systems and to other services as well.

The Patriot Vigilance Project

Personnel from the Army Research Laboratory's Human Research and Engineering Directorate (HRED) began looking into Patriot and AMD performance and training issues at the invitation of the then Ft. Bliss Commander, Major General (MG) Michael A. Vane. MG Vane was interested in operator vigilance and situation awareness (SA) as they relate to the performance of automated AMD battle command systems. [Note: The generally accepted definition of SA is from Endsley, Bolte, and Jones (2003) who define it as the *perception* of elements in the environment, the *comprehension* of their meaning, and the *projection* of their status in the near future.] MG Vane was particularly concerned by what he termed a "lack of vigilance" on the part of Patriot operators along with an apparent "lack of cognizance" of what was being presented to them on situation displays and a resulting "absolute trust in automation." His request for human factors support was prompted by the unacceptable rate of fratricidal engagements by Patriot units during OIF—two out of a total of 11 engagements, or 18%. MG Vane's reference to lack of vigilance by Patriot operators led to the effort being called the Patriot Vigilance project.

Following general approaches to human error investigations and case study research outlined in Dekker (2002) and Yin (2003), respectively, the project staff spent most of the summer and fall of 2004 performing a human-performance-oriented critical incident assessment of the OIF fratricides. This involved activities such as reading documents from the fratricide boards of inquiry (BOIs), interviewing knowledgeable personnel in the Ft. Bliss area, and observing Patriot training and operations. HRED's project leader also had extensive personal experience with Patriot and other AMD systems. He had, for example, (1) served as an air defense officer on the Nike Hercules system in the early 1970s, (2) directed several early concept development and training evaluation projects involving the Patriot system in the late '70s and early '80s, (3) directed the human factors portion of various operational tests for the Forward Area Air Defense systems in the late 1980s, and (4) worked with the AMD community to assess the results of the first use of the Patriot system in a missile defense role in the aftermath of ODS.

An initial assessment briefing was delivered to MG Vane in October 2004. The project staff also prepared a supporting technical report describing the human performance problems associated with automation and supervisory control (Hawley, Mares, & Giammanco, 2005). The logic model (see Yin, 2003) resulting from the critical incident assessment of the OIF fratricides is presented in figure 1. The first block in the causal network leading to the OIF fratricides is termed "undisciplined automation," defined as the automation of functions by designers and subsequent implementation by users without due regard for the consequences for human performance (Parasuraman & Riley, 1997). Undisciplined automation tends to define the operators' roles as by-products of the automation. Operators are expected to "take care of" whatever the system cannot handle. However, in the case of Patriot, little explicit attention was paid during design and subsequent testing to determining (1) what these residual functions were, (2) whether operators actually could perform them, (3) how they should be trained, or (4) the impact on the overall system's (hardware plus operators) decision-making reliability.

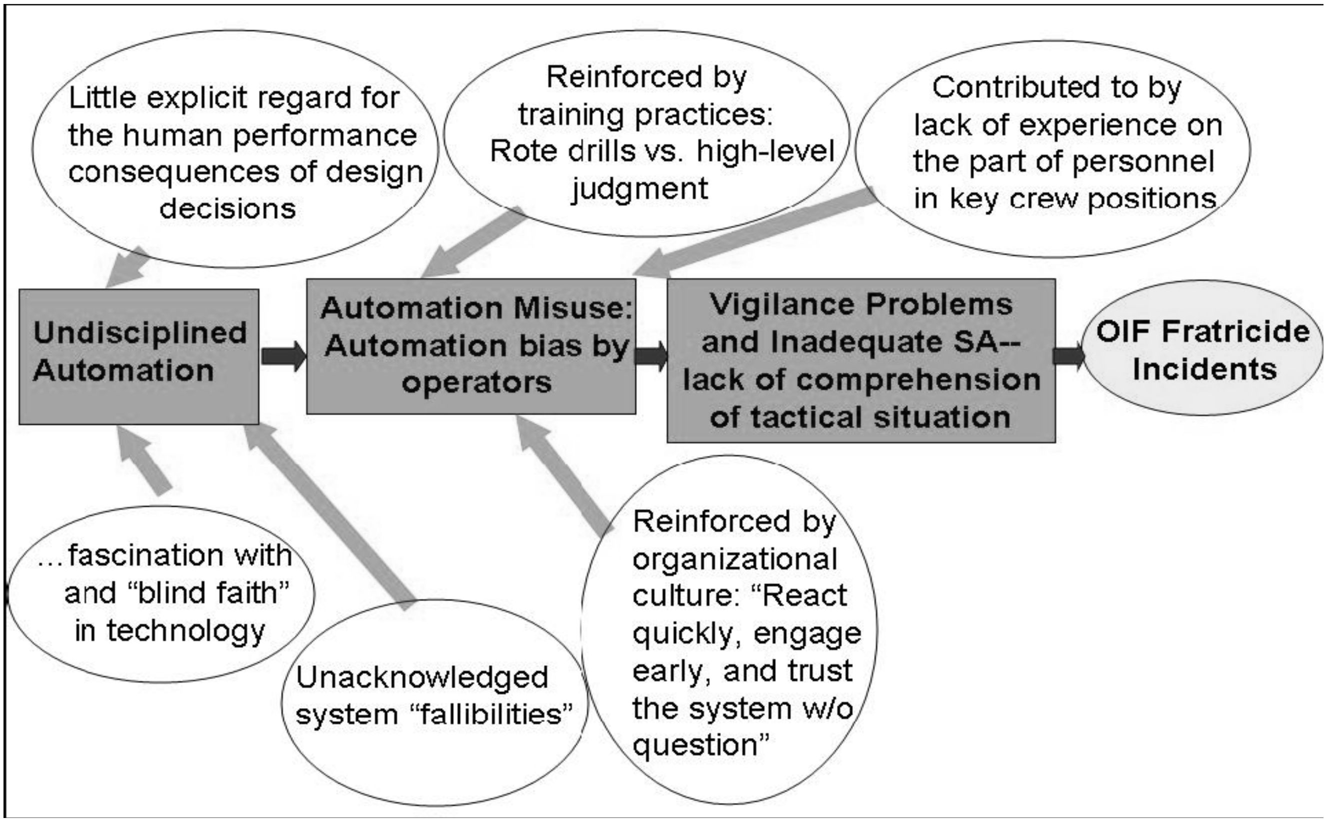

Figure 1. Patriot vigilance logic model.

The downstream impact of undisciplined automation was exacerbated by two additional factors: (1) unacknowledged system fallibilities, and (2) a "fascination with and blind faith in technology." [Note: Several terms presented in quotes without reference citations are taken from the classified BOI reports.] A series of Patriot operational tests indicated that the system's automated engagement logic was subject to track misclassification problems—system fallibilities. However, these sources of automation unreliability were not explicitly patched during system software upgrades, nor did information about them find its way into operator training; battle command practices; tactics, techniques, and procedures (TTPs); or Tactical Standing Operating Procedures (TSOPs). System developers continued to pursue technology-centric solutions to automation reliability problems (e.g., increased use of artificial intelligence, non-cooperative target recognition, etc.). But the basic problem remained: The total system (hardware plus crew) was unreliable in critical functional areas, most notably track classification and identification. Users were not informed regarding these problems, or if they were informed, little effective responsive action was taken.

In the aftermath of the first Gulf War (ODS), the AMD user community acquiesced to the developmental community's apparent lack of concern for problems with Patriot's track classification accuracy. Emboldened by Patriot's seeming success in engaging the Iraqi SCUD threat during ODS, Patriot's organizational culture emphasized "Reacting quickly, engaging early, and trusting the system without question." This cultural norm was exacerbated by the AMD branch's traditional training practices, which were criticized in BOI reports as emphasizing "rote drills versus the exercise of high-level judgment." The Patriot user community continued to approach training for Air Battle Operations in much the same manner as March Order and Emplacement or System Set-up. The emphasis was on mastering routines rather than active thinking and adaptive problem solving. Klein and Pierce (2001) refer to the result of this practice as "experiosclerosis." Crews believe they are competent and "combat ready" because they are good at the routines, but the routines can prove to be a strait jacket during combat. Traditional individual and unit evaluation practices reinforced this mistaken belief on the part of crews and commanders at all levels by focusing only on satisfactory performance of routine drills. The Army BOI investigating the OIF fratricides stated bluntly that "the system (Patriot) is too lethal to be placed in the hands of crews trained to such a limited standard."

A second detrimental factor was the Branch's traditional personnel assignment practices which tended to place inexperienced personnel in key crew positions in the C2 chain: the battery-level Patriot Engagement Control Station (ECS) and battalion-level Information and Coordination Central (ICC). Before the first round was fired during OIF, the stage was thus set for what Parasuraman and Riley (1997) refer to as "automation misuse," specifically automation bias on the part of Patriot operators. Automation bias is defined as unwarranted over-reliance on automation, and has been demonstrated to result in failures of monitoring (vigilance problems) and accompanying decision biases (an absolute and unthinking trust in automation—let's do what the machine recommends). Recall that these are the very concerns expressed by MG Vane in his kick-off discussion with the Patriot Vigilance staff.

One must be careful, however, not to lay too much blame for these shortcomings at the feet of the Patriot operators or the supporting battle staff. As suggested in figure 1, the roots of these human shortcomings can be traced back to systemic problems resulting from decisions made years earlier by concept developers, software engineers, procedures developers, trainers, and commanders. In one sense, the OIF Patriot operators did what they had been trained to do and what Patriot's culture emphasized and reinforced.

Hardware-wise, Patriot is a very lethal system. It can be argued, however, that the system was not properly managed during OIF. Driven by technology and mission expansion, the Patriot crew's role changed from traditional operators to supervisory controllers whose primary role is supervision of subordinate automatic control systems. But this role change was not reflected in the AMD culture, design and evaluation practices, battle management concepts, operational procedures, training practices, or personnel usage patterns. Moreover, system management issues (doctrine, battle command concepts, TTPs, TSOPs, etc.) and crewmembers' ability to execute them were not addressed with the same rigor during development and evaluation as hardware and software capabilities. As the lessons of OIF suggest, these aspects of the total "system" are as important to operational effectiveness as hardware and software capabilities.

HRED's briefing to MG Vane in October 2004 described the human performance circumstances that contributed to the fratricides and recommended two primary actionable items to address the problems thus identified:

1. Re-examine automation concepts, operator roles, and command and control (C2) relationships in AMD battle command systems to emphasize effective human supervisory control (HSC); and
2. Develop more effective missile crews and C2 teams, or in the words of the Army BOI report "re-look the level of *expertise* required to operate such a lethal system on the modern battlefield."

In present usage, the term effective HSC refers to a situation in which soldiers and not the automated system are the ultimate decision makers in AMD firing decisions. Uncritical acquiescence to the automated system's recommendations is not effective HSC.

A month following HRED's report to MG Vane, the Defense Science Board (DSB) (DSB, 2004) reinforced HRED's conclusions with the following recommendations. Although the full DSB report on Patriot system performance is classified, these extracts are not.

> "The Patriot system should migrate to more of a 'man-in-the-loop' philosophy versus a fully automated philosophy—providing operator awareness and control of engagement processes."

and

> "Patriot training and simulations should be upgraded to support this man-in-the-loop protocol including the ability to train on confusing and complex scenarios that contain unbriefed surprises."

A summary of the DSB report on Patriot system performance is available for download on the DSB's web site.

Follow-On Work, Implementation, and Current Status

After reviewing initial project results, the Army Training and Doctrine Command (TRADOC) System Manager for Lower Tier AMD systems (TSM-LT), requested that the Patriot Vigilance project continue into a second phase. The TSM specifically requested that HRED's project staff expand on the material presented in Hawley, Mares, and Giammanco (2005) and prepare two, more-detailed reports, one concerned with design for effective human supervisory control and a second addressing training for the emerging class of automated AMD battle command systems. In the TSM's words, the intent of these reports was to inform the AMD community on "what right looks like" in each of these topic areas. The results of the second phase of the effort were the technical reports *Developing Effective Human Supervisory Control for Air and Missile Defense Systems* (Hawley & Mares, 2006) and *Training for Effective Human Supervisory Control of Air and Missile Defense Systems* (Hawley, Mares, & Giammanco, 2006). Both reports contain a summary and discussion of the technical state of the art in each of the topic areas. In addition, supporting informational briefings were developed for use across the AMD community. The project staff also worked with various elements in the AMD system development, training, and user communities on operationally defining and implementing Patriot Vigilance recommendations. Phase two formed the theoretical basis for what later were to be turned into actual design and training modifications.

In the late summer of 2005 after MG Vane had left Ft. Bliss for another assignment, the project staff briefed his replacement, MG (then Brigadier General) Robert P. Lennox, on the status and results of the Patriot Vigilance project. Based on this presentation and subsequent urging from the TSM-LT, MG Lennox formally requested that the project be continued for at least another year so that the technical staff could continue to work with the AMD community on implementing selected results. HRED's project staff also would participate as the MANPRINT (Manpower and Personnel Integration) evaluator during an operational test of the Post-Deployment Build 6 (PDB-6) software suite for the Patriot system. PDB-6 was developed to address many of the Patriot system's operational deficiencies that had surfaced during OIF and were generally considered to have contributed to the unacceptable fratricide rate. MANPRINT is the Army's Human Systems Integration (HSI) initiative.

It later turned out that in addition to wide-ranging software fixes (more than 20% of the system's battle command software had been changed), the PDB-6 operational test was expanded to address a number of changes consistent with HRED's first actionable item concerning a re-examination of automation concepts, operator roles, and C2 relationships in AMD battle command systems to emphasize effective HSC. The centerpiece of these changes was the integration of a Fire Coordination Cell (FCC) into the Patriot battalion command post. The FCC represents an enhanced C2 entity similar in concept to the combat information center on Navy Aegis cruisers. If the FCC concept proved successful, it rather than the traditional ECS-ICC combination would become the "trigger-puller" for Patriot units. With the introduction of the FCC, the branch was implicitly recognizing that "two people inside a van (the ECS) conducting engagement operations is no longer viable." The FCC potentially represents a significant step forward in addressing the SA problem that contributed to the C2 failures of OIF. First, however, it would have to be demonstrated (1) that the FCC provided the incremental SA essential for more accurate engagement decision making and (2) that the new C2 configuration could do so in a timely manner. Engagement decision time lines for Patriot against TBMs are very short—less than 10 seconds in the case of the fratricide involving the British Tornado during OIF. Decision cycle time is a significant issue in AMD battle command.

From the fall of 2005 through the summer of 2006 during the New Equipment Training (NET) and unit train-up period for the PDB-6 test, the HRED project staff's observations regarding the progress of training for the test unit sounded an alarm bell loudly. PDB-6 training was not progressing according to plan. Training events were being completed, but individual and crew performance objectives were not being met. In addition, many of the training issues identified and discussed in Hawley, Mares, and Giammanco (2006) were surfacing and were not being addressed adequately by the NET process or follow-on collective training by the test unit. These included but were not limited to (1) an emphasis on training events to the exclusion of test player performance capabilities, (2) lack of focus on the unit's core test mission—Air Battle Operations, (3) inadequate standards, (4) inappropriate training methods, and (5) inadequate performance feedback—the after-action review (AAR) process.

The project staff viewed these deficiencies as a serious problem because inadequate test player training would compromise the validity of test results and undermine the basis for evaluating the value added of PDB-6 software changes, the FCC concept, and other C2 modifications (Hawley, 2007). Even more serious was the fact that fratricides and fratricide-inducing conditions (dropped or improperly correlated tracks, loss of network connectivity, etc.) similar to those that occurred during OIF were still all-too-frequent during the test itself. Many of the human performance problems that had shown up during OIF were apparent again, with similar results.

What's Going On Here?

The underlying problem in OIF and observed in the PDB-6 test is that the new generation of information-dominant, network-centric systems exemplified by Patriot is complex and typically requires a high level of expertise for effective use. Moreover, many of these new systems are not systems in the traditional military use of the term—a single item of equipment. Rather, "the system" often is a capabilities increment brought about through changes in doctrine or tactics partly based in software, partly based in user procedures, and supported by various items of commercial or government off-the-shelf equipment—all networked together and linked with other similar systems. In a review of the evolution of operational warfare since World War II, Citino (2004) observes that success in the emerging warfighting environment is more a function of "soft" factors such as doctrine, procedures, and leadership than technology per se. Citino's observation speaks directly to the importance of viewing the system as a whole—hardware, software, people, organization, operational concepts (e.g., doctrine and tactics), and procedures—rather than just the hardware component by itself.

Increased complexity results from a large number of interacting components and the amount of information required to characterize and comprehend the system. Norman (2002) cites results suggesting that complexity for users is a non-linear function of the number of interacting components coupled with information density. Dekker (2002) further observes that systems having these characteristics require an "overwhelming human contribution" for their effective operation. He states that "people are the only ones who can hold together the patchwork of technologies in their worlds; the only ones who can make it work in actual practice" (p. 103). A paradox of the emerging high-technology warfighting environment is that automation and other advanced technologies reduce the moment to moment need for humans while simultaneously increasing their criticality to overall system effectiveness. Contrary to much popular belief, a system's training load is a direct pass-through of operational complexity.

At the same time that user proficiency is becoming increasingly critical to effective system performance, preparing users to perform at the levels required to achieve system goals is becoming more involved. This problem results from two related factors:

1. New systems and technology are more interactive with unit operations than was the case in the past.
2. It can be argued that we now field new organizations rather than systems in the traditional sense.

The impact of the first factor is illustrated graphically in Figure 2. When the M1 tank was introduced into a formerly M60 tank unit, the improved tank did not materially change the receiving organization. Yes, the M1 was faster and could shoot further than an M60, but the organization was still a traditional armored unit and was fought much the same way. With the introduction of the Stryker vehicle and associated technology, this situation began to change. It was envisioned that the much lighter Stryker organization would rely on technology to perform many of the functions carried out previously by armored organizations. Lighter armor and less gun-punch would be offset by technology and changes in doctrine and procedures. One could not fight a Stryker organization like an M1 unit and expect to survive and succeed. The newer Stryker technology thus brought with it a requirement for significant changes in the way the receiving organization did business—and many of these changes involved the soft factors noted previously. Further, the training impact of these changes is significant. The trend illustrated with Stryker will continue and accelerate with the fielding of brigade combat teams (BCTs) equipped with Future Combat Systems (FCS) technology and in other domains involving so-called systems of systems.

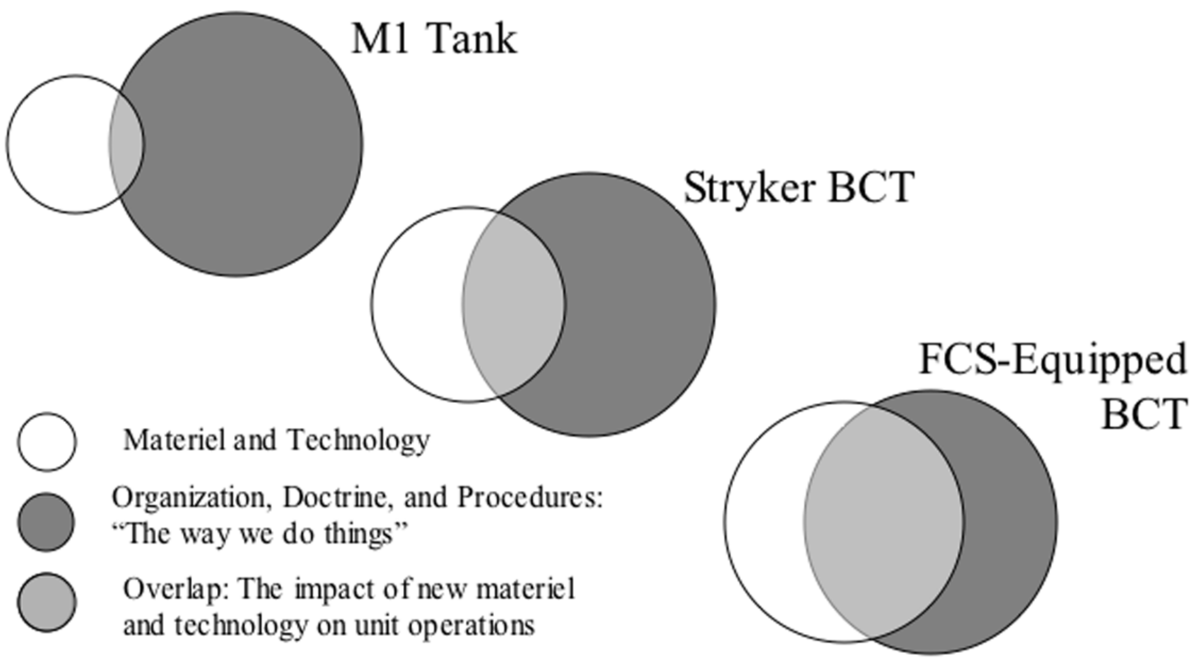

Figure 2. The changing nature of systems acquisition.

Because of the phenomenon described in the previous paragraph, the unit equipped with a new system often is a new organization rather than a traditional organization equipped with a new materiel system. Beginning with the Army's so-called Digital Division and later with the Stryker

BCT, technology infusions have created new organizations. In the words of the Stryker Brigade Coordination Cell (BCC) (Stryker BCC, 2003):

> "Stryker BCTs are complex organizations. Transformation of the BCT is much more than conducting NET (New Equipment Training), and essentially is a holistic effort required to convert to a new organization, receive new equipment, and ultimately train to a higher level of unit proficiency."

Converting to a new organization requires that the training program for new systems recognize how organizations acquire competence. Of necessity, organizational competence building must progress much as described in Figure 3: Individual training followed by work group (crew or team) training, followed by multi-echelon unit training. This approach would seem to reflect common knowledge and practice, but it is surprising how infrequently the issue of organizational competence building addressed in unit change over to new systems. The approach was not applied during the pre-test training period for Patriot PDB-6.

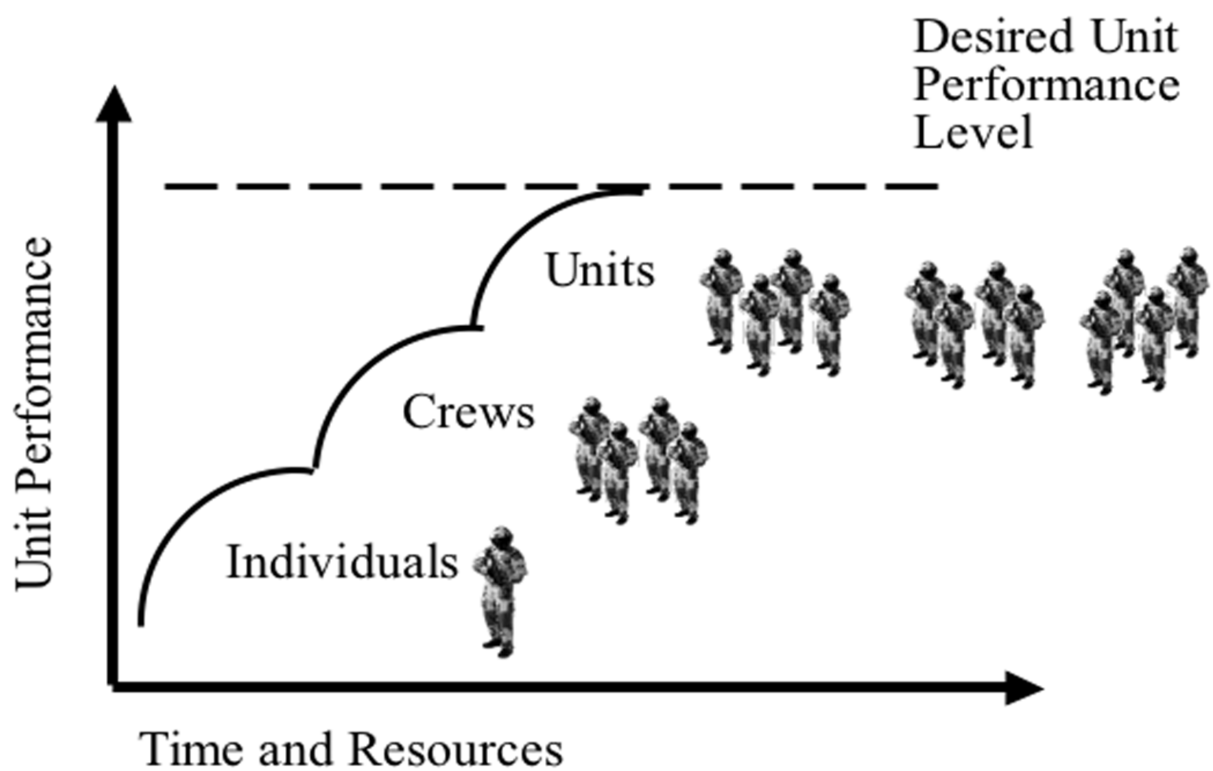

Figure 3. Developing organizational competence.

The major roadblocks to implementing an organizational competence approach to training are:

1. Organizational competence building requires more time and resources than are typically planned or actually allocated for new system training, and

2. Organizational competence building brings with it more complex issues not typically addressed during training planning for new systems.

These latter issues include modified doctrine and procedures, new command and control relationships, and multi-echelon leader training and development.

Beyond the quantitative factors discussed in the previous paragraphs, training for the new class of systems also must be qualitatively different. The issue here is that the new class of technology-dominated systems is complex and knowledge-intensive. Knowledge-intensive systems shift the focus of user performance from what are referred to as skill- and rule-based performances to knowledge-based performances (Rasmussen, 1986; Dekker, 2002). Rasmussen remarks that knowledge-based performances are goal-oriented and determined on occasion through conscious problem solving and planning. Dekker (2002) notes that what distinguishes "good" decision makers from "poor" decision makers in knowledge-intensive job settings is their ability to make sense of situations using a highly organized experience base of relevant knowledge.

Most current Army training—including that for Patriot—stresses skill- and rule-based performances but does not emphasize knowledge-based performance requirements. To illustrate this point, recall that the BOI looking into the fratricides involving Patriot during OIF criticized pre-deployment training for emphasizing rote drills versus high-level judgment. Rote drills focus on skill- and rule-based performances like operating equipment or following procedures; exercising high-level judgment is a knowledge-based performance.

The crux of the above discussion is that knowledge-intensive systems place a premium on user expertise. In present usage, the term expertise refers to a capability for consistently superior performance on a specified set of representative tasks for a domain (Ericsson & Charness, 1994). Expertise is a function of user knowledge, skill, and job-relevant experience. The need for a high level of expertise means that marginally-skilled users cannot employ a complex system to its full potential, regardless of the sophistication of the control suite provided to them. Technology can amplify human expertise, but cannot substitute for it—and might even be detrimental if the necessary expertise is not present.

Given the centrality of user expertise in the emerging warfighting environment, an obvious follow-on question is, "How is such expertise developed?" Norman (1993) notes that there are at least three phases of learning leading to expertise as defined above. These are (1) accretion, (2) tuning, and (3) restructuring. Accretion is the accumulation of facts. Tuning refers to the process of translating knowledge into skill. The final stage of learning is restructuring, or forming and reforming the proper conceptual framework for performing as an expert—the sensemaking ability referred to previously. Norman further remarks that accretion and tuning are primarily experiential—they take place actively in an experience-based learning environment. Restructuring is reflective. It involves exploring the domain in depth, forming comparisons, and integrating across related domains. The complete process requires a hands-on learning environment and hours and hours of practice under the supervision of a coach or mentor. Such feedback-intensive training is referred to as deliberate practice. How many hours are necessary? Norman asserts that for any complex activity, a minimum of 5,000 hours of practice—two years of full-time effort—are required to turn a novice into an entry-level expert. Expert, in this context, refers to a user who has developed the sensemaking capability necessary to perform appropriately in a knowledge-intensive job setting. It should be noted, however, that the 5,000-hour rule applies to all training and job preparation relevant to a performance domain: institutional training, on-the-job-training (OJT), special skills training, and the like. The training implications of the preceding discussion are clear: If highly-skilled human performance is required to exploit a system's capability, there is no way to avoid Norman's 5,000-hour rule for the development of entry-level expert performance capabilities.

These observations regarding the human performance impact of advanced technology are not particularly new or unique to AMD. For example, in her classic work *In the Age of the Smart Machine*, Shoshanna Zuboff (1988) remarks that computer-mediated work like that found in most new systems brings with it an increase in "intellective skill requirements." Commenting on what they had observed during ODS in the early 1990s, Cordesman and Wagner (1996, p. 25) note that technical advances are used to demand more from operators, and meeting these demands often requires "exceptional human expertise." In the first of two reports on training for future conflicts, the DSB (2001) cautioned that an increasing risk exists that training failures will negate hardware promise. Their 2003 follow-on report further remarked that the future will require that more of our people do new and more complicated things, and "meeting this challenge amounts to a qualitative change in the demands placed on our people that cannot be supported by traditional training practices" (DSB, 2003, p. 38). More recently, an early operational assessment of DARPA's Command Post of the Future (CPOF) currently being used by the Army in Iraq remarks that in order to take advantage of the features provided by this new capability there is a "need for a soldier with a wider 'intellectual bandwidth,' where management and assimilation of information from many sources is a necessity" (Center for Army Lessons Learned, 2005, p. vii). In a case study assessment of the impact of net-centric operations using the Stryker BCT as an exemplar, Gonzales, Johnson, McEver, Leedom, Kingston, and Tseng (2005, p. 35) concluded that "training is more important than ever in the Stryker brigade and other digitized units because the networking and battle command systems employed are more complex than those used in analog-equipped brigades. If soldiers and commanders are not adequately trained on the NCW [network-centric warfare] systems and are not proficient in their use in stressful battlefield conditions, then these NCW systems can be a hindrance rather than a help in combat." Finally, in a post-test briefing to the Vice Chief of Staff of the Army concerning the Army Battle Command and Enablers (ABCE) system of systems, the Army Test and Evaluation Command (ATEC) concluded "There is no indication that units can dedicate the time, resources, or personnel to adequately train on the digital C4I systems and allow the unit to adequately comprehend the system's capabilities, much less exploit these systems as a force multiplier" (ATEC, 2006).

Considering the previous quote about training problems associated with the ABCE system of systems, nearly the same comment could be made concerning the results of the Patriot PDB-6 test. However, a qualification to this conclusion is in order: There is no indication that units can adequately train for the emerging class of knowledge-intensive systems following traditional training and personnel management concepts and practices. Converging patterns of evidence suggest that current concepts and practices in both areas must change. If changes are not made, there is a high risk that performance expectations will not be met, as the DSB earlier cautioned. Essential changes in both areas are discussed in the next section.

What Has to Happen?

The discussion of solutions to the problem of developing effective and adaptive 21st century warfighters is organized into two sections. These are:

1. Job preparation
2. Personnel and staffing

Job Preparation

The primary lesson emerging from the Patriot experience during OIF and follow-on work through the PDB-6 operational test is that job preparation for knowledge-intensive systems must be quantitatively and qualitatively different from current practices. In present context, the term job preparation refers to all of the actions and activities that lead up to a soldier being assigned to an operational position. Job preparation consists of basic military training, advanced individual training, various phases of collective training, professional development, and on-the-job experience. It also includes the implicit job preparation that takes place by being in and around an operational unit—what Sternberg et al.(2000) refer to as tacit knowledge. Used in this manner, the term job preparation is much broader than current Army concepts regarding training and job qualification.

One of the principal arguments advanced in the present paper is that job preparation for knowledge-intensive systems must shift from a simple concern for task-related knowledge and skill to job-related expertise and adaptability. Expertise is a function of knowledge, skills, and job-relevant experience. Experience is essential to tuning the mental models that underlie performance adaptability. Extensive Army literature emphasizes that adaptive individuals and teams are necessary to cope with the uncertainty that is expected to characterize future operations. Individuals and teams must be able to make the necessary modifications to meet emergent challenges. Crews must expect to modify or replace plans. They must expect to improvise to meet changing operational contingencies.

As desirable and important as adaptive expertise might be, producing adaptive individuals and crews will not be a simple undertaking. Klein and Pierce (2001) caution that most teams can become adaptive, but most will not. Why not? At least three roadblocks stand in the way:

1. Time and job progression practices

2. Training quality

3. Trainee motivation

First, achieving adaptive expertise will require more time for training than the Army has traditionally allocated for user job preparation. Simply put, there is no way to avoid the 5,000 hour rule that applies in other high-skill situations. Further, intra-unit job progression patterns will have to change. Operator trainees might have to spend an extended period in an apprentice status while they acquire the skills and experience necessary for effective job performance. Unit metrics regarding what constitutes qualified individuals and crews also will have to change, and it is not certain that current personnel management practices and concerns (e.g., career progression "gates," up-or-out rules, etc.) can accommodate such requirements. The issue of personnel and staffing practices is addressed in more detail in the next section.

Second, many qualitative aspects of user training will have to change. To begin, training will have to be more rigorous and performance-oriented than at present. Training content and scenarios must reflect job requirements, and standards must be rigorously applied across the board. Introductory, baseline training will have to be followed by crew-oriented training that emphasizes active thinking and fluid decision-making within an adaptive network of roles (Kozlowski, 1998). This will require intact crews and—above all—time to form this collective expertise.

Third, trainees must be motivated to develop the deep expertise in technology, weapons systems, and operations necessary to inform the decision processes that characterize being adaptive. Trainees, commanders, and the general Army culture must accept that preparation for the emerging generation of knowledge-intensive military jobs involves no less professionalism than preparation for aviation or any other high-skill job in or out of the military. The topics and focus are different, but the preparatory requirements are similar.

Personnel and Staffing

The second major area where change must occur concerns personnel and staffing practices. Put bluntly, the Army's personnel management system must support the development of individual, crew, and unit competence rather than impede it. For example, a review of the battle rosters for missile crews and C2 teams participating in the PDB-6 test indicated that personnel-wise the unit was a very turbulent place. Unit personnel turbulence resulted from transfers (both in and out), expirations of term of service, disciplinary problems, pregnancies, attendance at special schools, and the list of factors goes on. Consequently, only slightly more than half of the personnel participating in the test attended NET, and stable missile crews and C2 teams were the exception rather than the rule. When an inquiry was made regarding whether this situation was "normal," the unit's response was that what the project team observed during the train-up period for the PDB-6 test was the normal state of affairs for units in garrison. Turbulence at this level makes it virtually impossible to develop competent individuals and crews of the sort required to effectively employ a knowledge-intensive system.

Others also have commented on the detrimental impact of current personnel practices. For example, the DSB noted that personnel policies have a huge influence on unit readiness, and that personnel turbulence limits unit performance by playing "musical chairs" with unit manning (DSB, 2003). This comment is a paraphrase of what HRED's project team observed during the PDB-6 test. The DSB warned that the current personnel system will not deliver the higher levels of cohesion that warfare transformation will require. Vandergriff (2002) echoes the DSB's concerns. In his book *The Path to Victory*, Vandergriff asserts that personnel turbulence degrades unit readiness by denying units the stability necessary to develop job and unit expertise. He warns that the Army's personnel system has evolved into the "tail that wags the dog," and ads that entrenched vested interests and bureaucratic inertia will make meaningful changes to traditional personnel practices very difficult to achieve. Reformed training practices overlaid on current personnel practices might not produce desired results.

So what is to be done? Vandergriff and others (e.g., Macgregor, 2003) advocate moving away from the current individual replacement system (IRS) and implementing some variant of a unit manning system (UMS). Others, such as the DSB, are not so certain that a UMS will provide a solution to the turbulence-unit readiness problem. For example, the DSB with all of its expertise and resources would not offer a solution to the personnel turbulence problem. Their discussion of the problem implied that offering up a comprehensive solution on that topic was beyond their competence.

A workable solution to the personnel management problem may not be as elusive as implied in the previous paragraph. An example from the Army aviation community might clarify and illustrate this point. Army aviation uses a special warrant officer career progression track to increase professionalism and expertise among aviators. Warrant officer aviators are officers, are highly selected, are granted honor and deference by all concerned, and are *expected* to be highly trained professionals who operate at the highest levels of expertise. Moreover, it is anecdotally reported that instructor pilots demand more of warrant officer students than of commissioned officer students (D.M. Johnson, personal communication, January 10, 2006). Commissioned officer students eventually grow up and become staff officers, administrators, and commanders; but warrant officer students develop as expert aviators and remain in this role throughout their careers.

It can be argued that the jobs of the personnel who will employ the emerging generation of knowledge-intensive, non-aviation systems will be no less demanding than those of Army aviators, and job preparation and career progression for these personnel must be approached in a similar manner. The Army's personnel system manages to accommodate the requirement for aviation personnel to maintain their flying skills. Why cannot similar provisions be made for other job categories? An apparently workable model exists in the aviation community; and perhaps it needs to be generalized to non-aviation job categories. A good first start is to recognize the impact of the turbulence problem, identify what has to happen to address the problem, and then determine what changes in personnel practices are necessary to achieve those ends.

Conclusion

In the report *Training for Future Conflicts*, the DSB asserts that the future will require that more of our people do new and more complicated things (DSB, 2003). Recall that the same report also remarks that meeting this challenge will require qualitative changes in the demands placed upon our people that cannot be supported by traditional training practices. Decision makers must come to grips with issues of training time and the quality of training experiences. They also must recognize that the Army's "crew drill" mentality is a major part of the problem associated with preparing soldiers for knowledge-intensive jobs. The crew drill mentality discourages active thinking and almost guarantees a drift toward automatic, unthinking operating procedures of the kind that produced the OIF fratricides. In a 1987 report titled *Lessons Learned to Date*, the Walter Reed Army Institute of Research (WRAIR as cited in Vandergriff, 2002, p. 268-269) remarked that the Army's training and personnel systems are "based on the fundamental concept of industrial mass production. Soldiers [are] defined as interchangeable parts in systems that require stereotyped behaviors ('by the numbers')." In essence, similar conclusions were reached by the post-OIF Patriot BOIs, HRED's incident assessment, and the DSB report on Patriot system performance. These points also reflect an implicit set of training and personnel practices that the Army must explicitly move away from.

The DSB's 2003 report concluded that training transformation to support warfare transformation will be a challenging undertaking. Old concepts and practices will have to change, but it has been noted that we often resist changing how we implement change. It is too easy to beat the drums loudly for change but fall back into old, familiar behavior patterns—with the result that no significant change actually occurs. Real change requires sustained real changes. In *The Path to Victory*, Vandergriff (2002) advocates a "revolution in human affairs" (RHA) to parallel the so-called "revolution in military affairs" (RMA) made possible by advances in technology. This paper has lightly touched upon two components of that RHA—training and personnel reform. Recall also the DSB's warning about an increasing risk of training failure negating technology promise. The converging trends discussed throughout this paper support the DSB's observation. An increasingly strong case can be made for the position that while technological opportunities might be the catalyst for an RMA, failure to address the parallel and equally important RHA has the potential to block that RMA's potential. Simply put, the performance promise of the emerging generation of technology-intensive systems will not be realized without significant changes in training and personnel practices. To remove these impediments, some parts of the Army are going to have to begin making the transition from the industrial age to the information age—from U.S. Steel to Microsoft, with all of the human resource challenges this analogy implies.

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